

CATHIE-RIKEN Workshop:

*Critical Assessment of Theory
and Experiment on Correlations at RHIC*

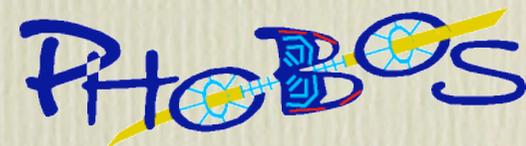
February 25-26, 2009



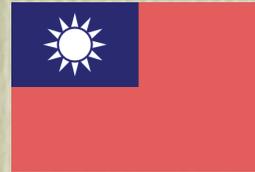
Validating the PHOBOS Implementation of ZYAM in Triggered Correlations at Large $\Delta\eta$



Edward Wenger
February 26th, 2008



PHOBOS Collaboration

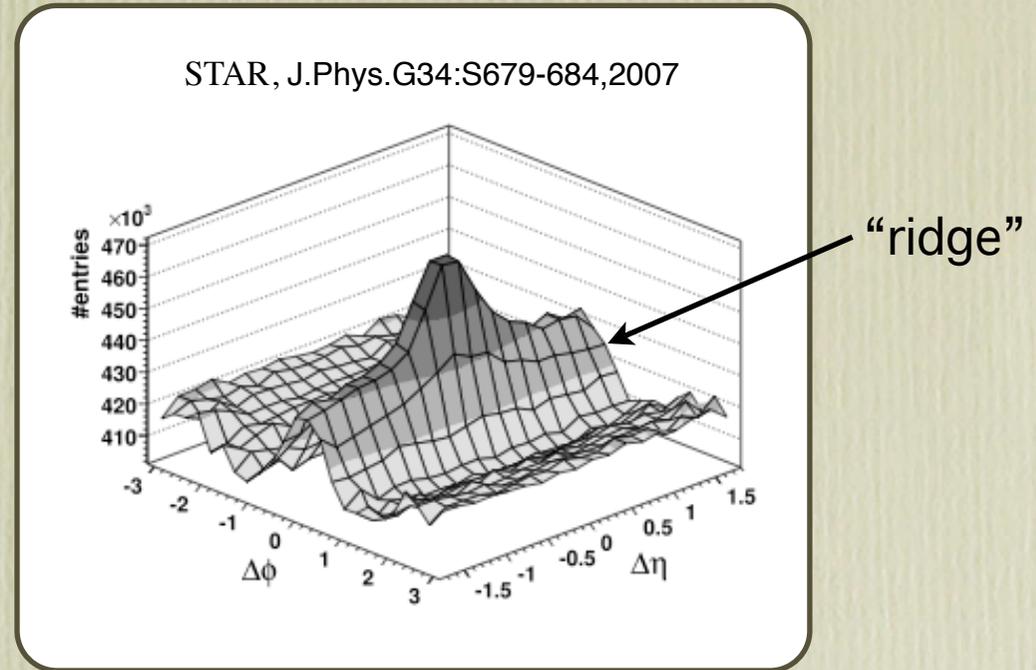
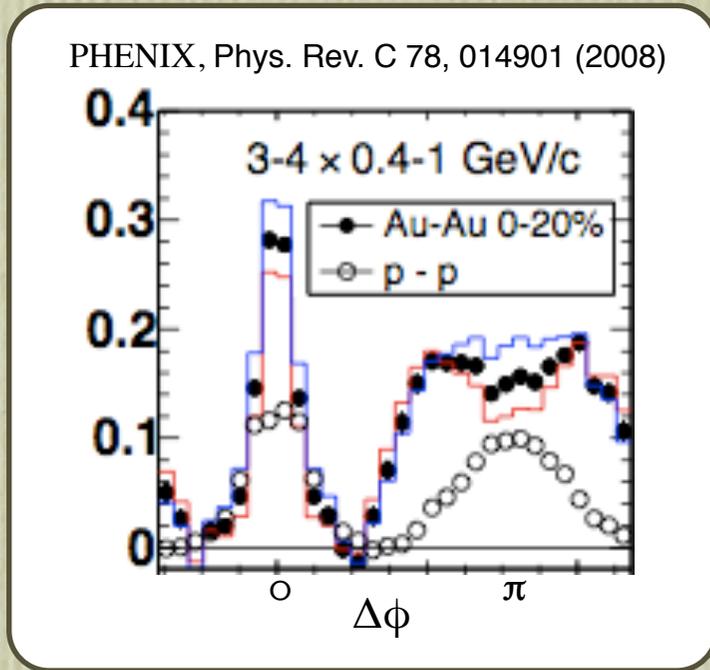


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UNIVERSITY OF MARYLAND

BROOKHAVEN NATIONAL LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
UNIVERSITY OF ILLINOIS AT CHICAGO
UNIVERSITY OF ROCHESTER

Motivation from previous results



Medium response to high- p_T probes near mid-rapidity

- ✓ broadening in $\Delta\phi$ of away-side compared to p+p
- ✓ enhanced correlation ("ridge") at $\Delta\phi=0$ and large $\Delta\eta$

PHOBOS Experimental Setup

High p_T trigger tracks

$$p_T > 2.5 \text{ GeV}/c$$

$$0 < \eta_{\text{trig}} < 1.5$$

Associated hits

Full φ coverage

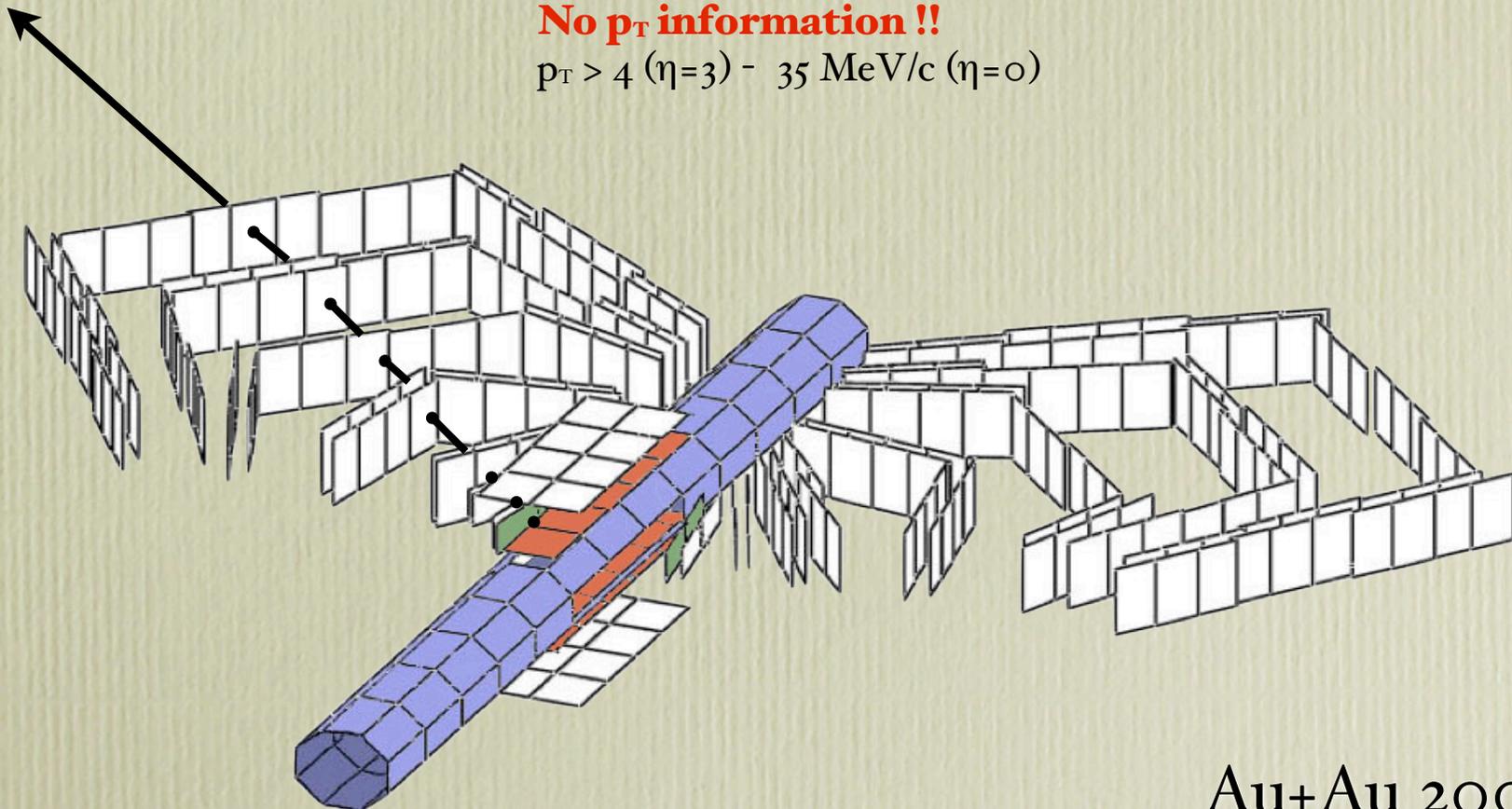
Broad η coverage ($-3 < \eta < 3$)

Single layer of silicon

No p_T information !!

$$p_T > 4 \text{ (}\eta=3\text{)} - 35 \text{ MeV}/c \text{ (}\eta=0\text{)}$$

Octagon holes are filled using hits from the first layers of the **Spectrometer** and **Vertex** detectors



Au+Au 200 GeV

Construction of correlated yield

$$\frac{1}{N_{\text{trig}}} \frac{d^2 N_{\text{ch}}}{d\Delta\phi d\Delta\eta} = \mathbf{B}(\Delta\eta) \left\{ \frac{s(\Delta\phi, \Delta\eta)}{b(\Delta\phi, \Delta\eta)} - a(\Delta\eta) [1 + 2V(\Delta\eta) \cos(2\Delta\phi)] \right\}$$

$$\frac{s(\Delta\phi, \Delta\eta)}{b(\Delta\phi, \Delta\eta)}$$

Raw correlation: ratio of per-trigger same event pairs to mixed event pairs

$$1 + 2V(\Delta\eta) \cos(2\Delta\phi)$$

Elliptic Flow: $V(\Delta\eta) = \langle v_2^{\text{trig}} \rangle \langle v_2^{\text{assoc}} \rangle$

$$a(\Delta\eta)$$

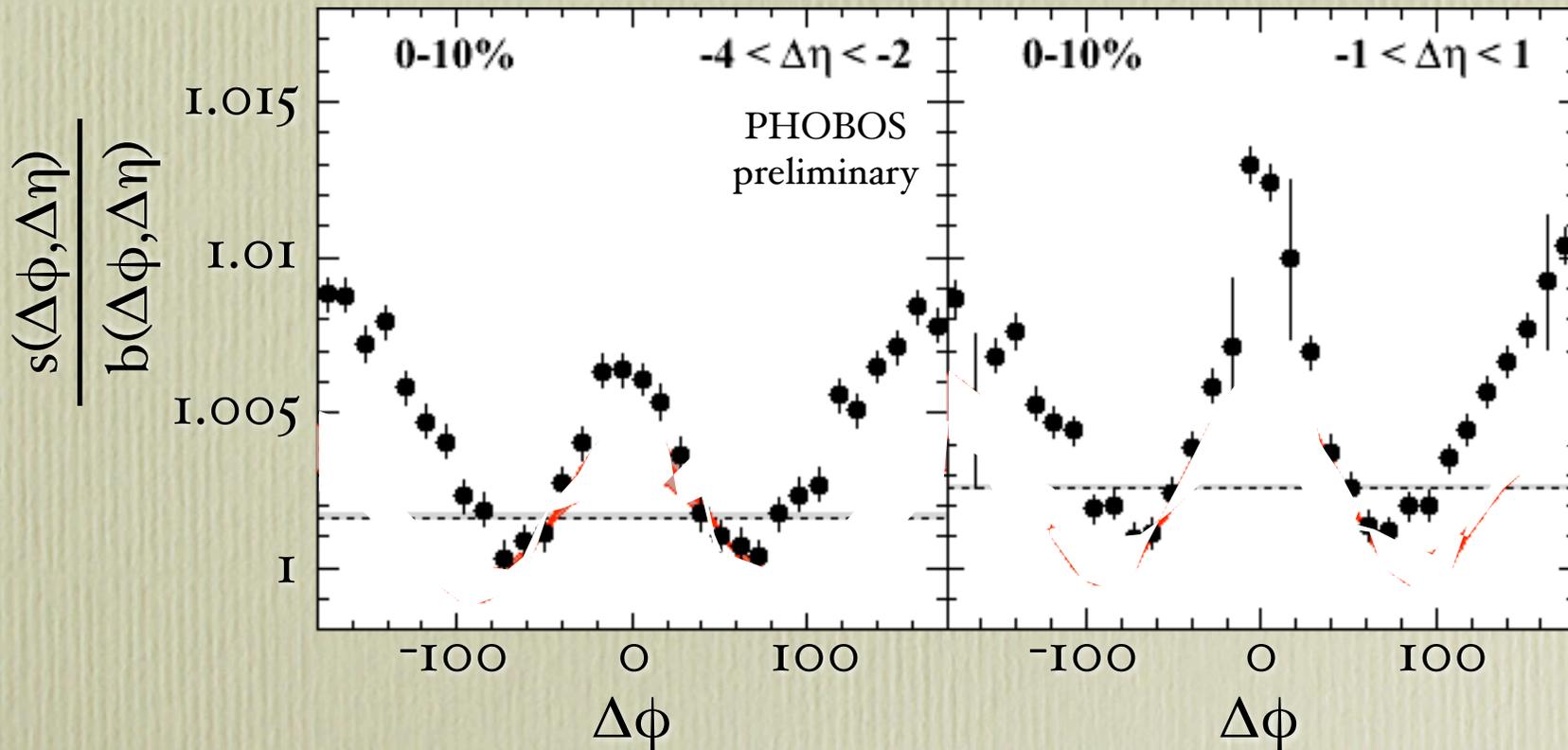
ZYAM factor: function of $\Delta\eta$

$$B(\Delta\eta)$$

Normalization term: relates flow-subtracted correlation to correlated yield

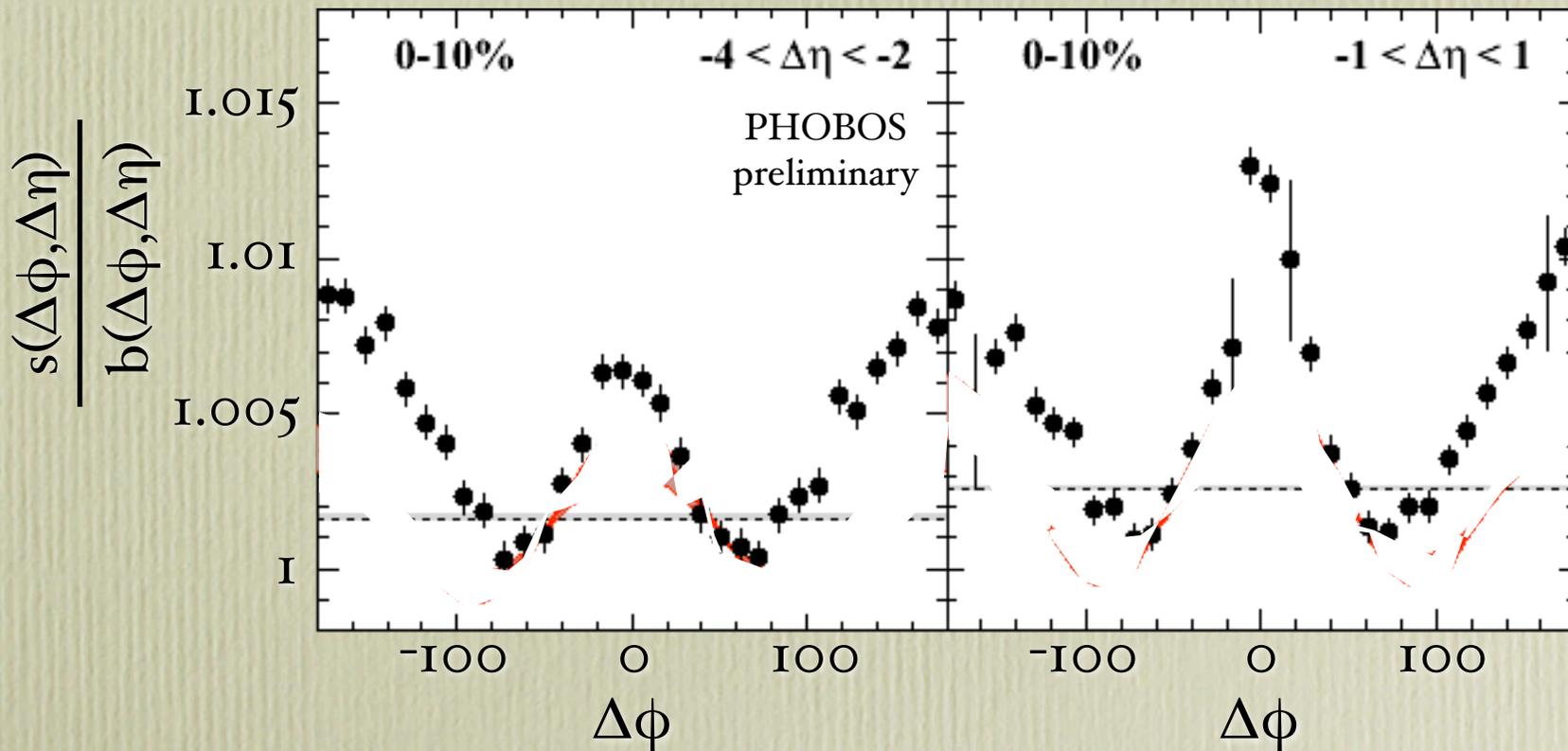
Subtraction of Elliptic Flow

$$\frac{1}{N_{\text{trig}}} \frac{d^2 N_{\text{ch}}}{d\Delta\phi d\Delta\eta} = \mathbf{B(\Delta\eta)} \left\{ \frac{s(\Delta\phi, \Delta\eta)}{b(\Delta\phi, \Delta\eta)} - a(\Delta\eta) [1 + 2V(\Delta\eta) \cos(2\Delta\phi)] \right\}$$



Subtraction of Elliptic Flow

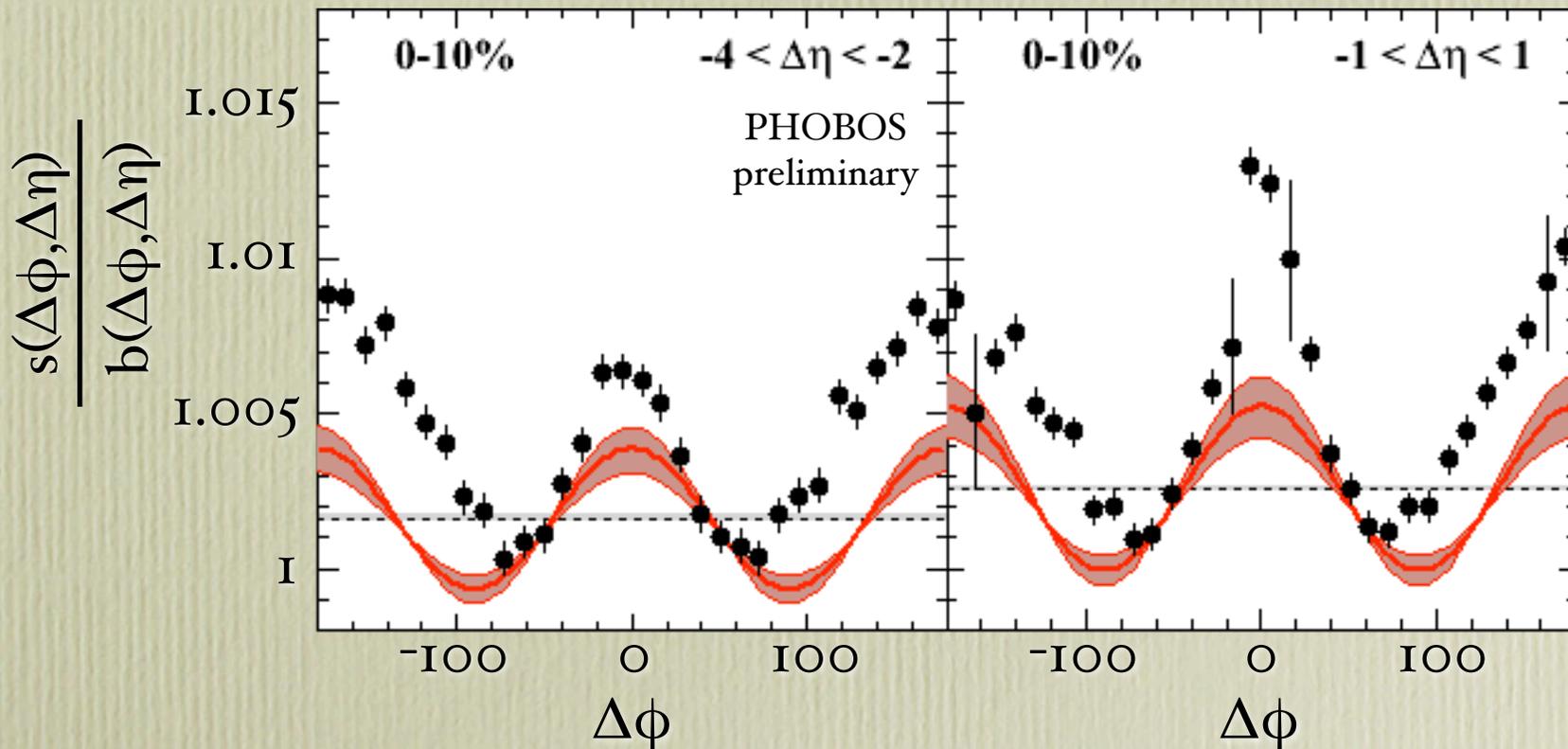
$$\frac{1}{N_{\text{trig}}} \frac{d^2 N_{\text{ch}}}{d\Delta\phi d\Delta\eta} = B(\Delta\eta) \left\{ \frac{s(\Delta\phi, \Delta\eta)}{b(\Delta\phi, \Delta\eta)} - a(\Delta\eta) \left[1 + 2V(\Delta\eta) \cos(2\Delta\phi) \right] \right\}$$



flow parameterized
from published
PHOBOS
measurements

Subtraction of Elliptic Flow

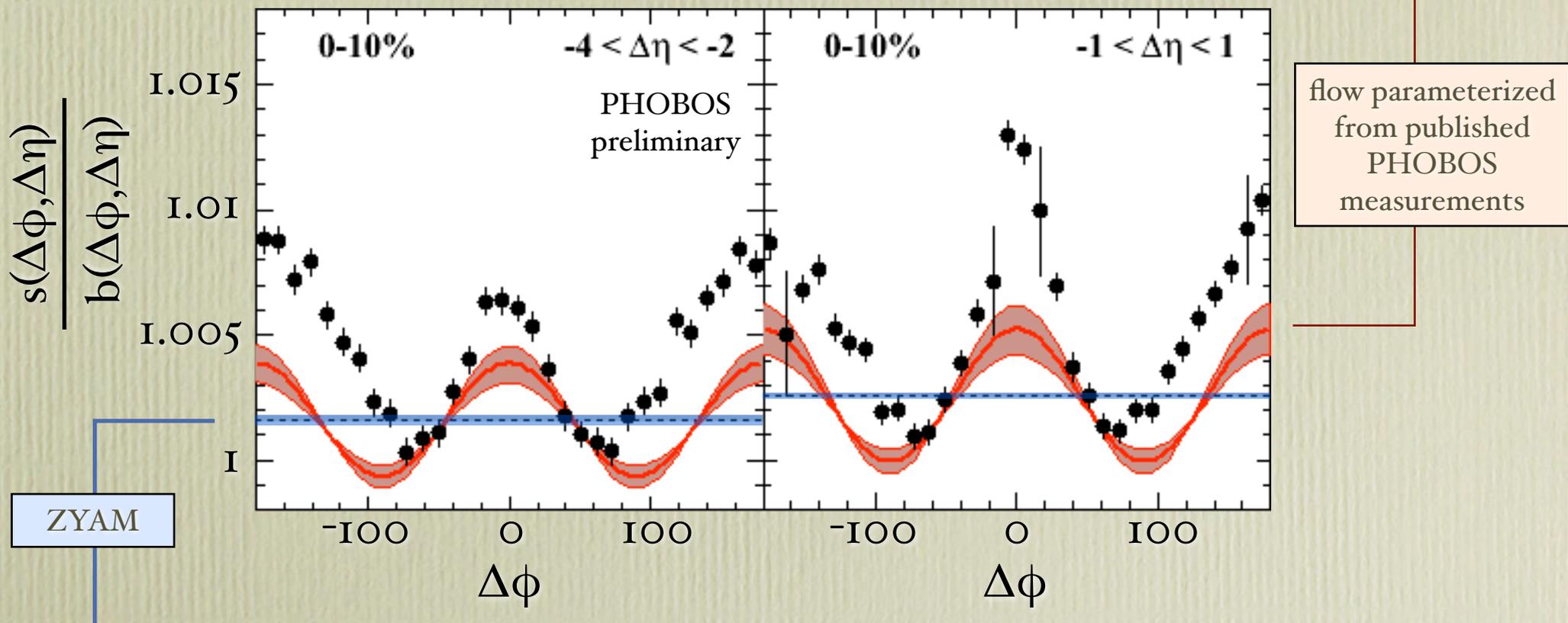
$$\frac{1}{N_{\text{trig}}} \frac{d^2 N_{\text{ch}}}{d\Delta\phi d\Delta\eta} = \mathbf{B}(\Delta\eta) \left\{ \frac{s(\Delta\phi, \Delta\eta)}{b(\Delta\phi, \Delta\eta)} - a(\Delta\eta) \left[\mathbf{1} + 2V(\Delta\eta) \cos(2\Delta\phi) \right] \right\}$$



flow parameterized from published PHOBOS measurements

Subtraction of Elliptic Flow

$$\frac{1}{N_{\text{trig}}} \frac{d^2 N_{\text{ch}}}{d\Delta\phi d\Delta\eta} = \mathbf{B}(\Delta\eta) \left\{ \frac{s(\Delta\phi, \Delta\eta)}{b(\Delta\phi, \Delta\eta)} - \mathbf{a}(\Delta\eta) \left[\mathbf{1} + 2V(\Delta\eta) \cos(2\Delta\phi) \right] \right\}$$

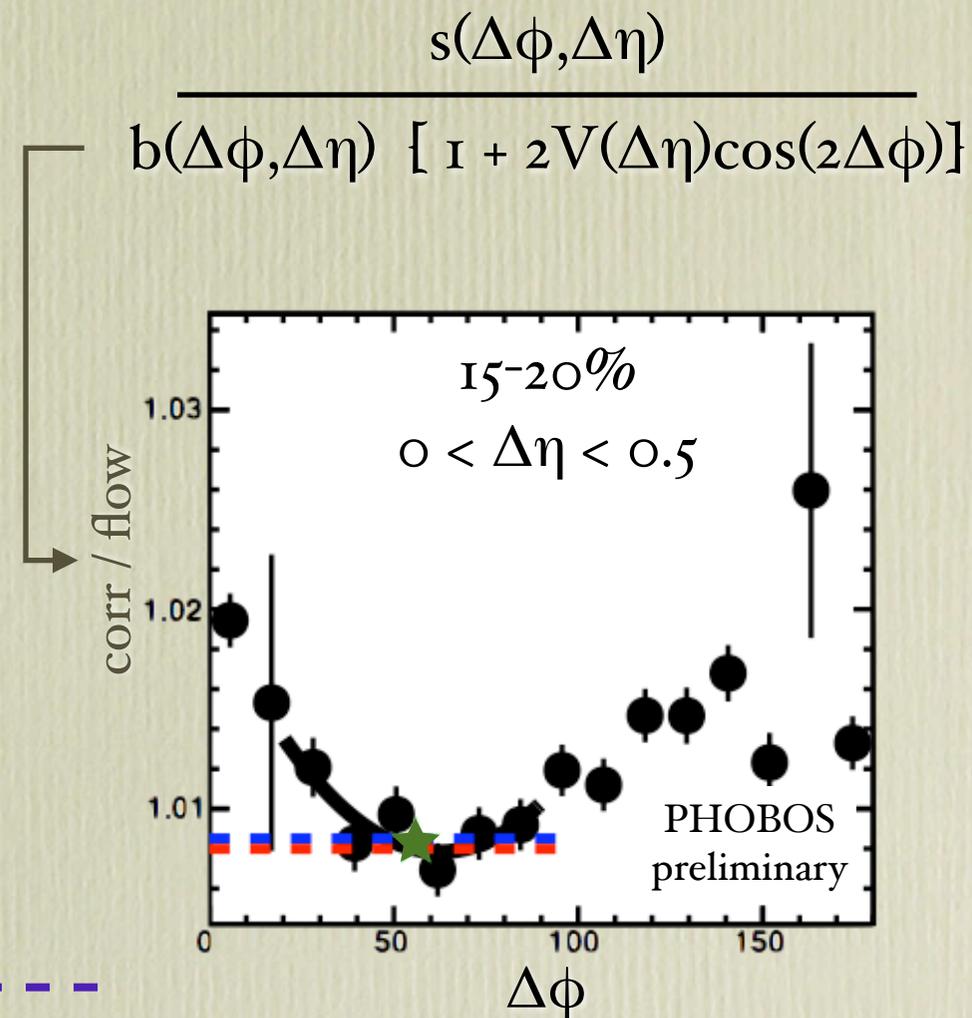


$\mathbf{a}(\Delta\eta)$ is calculated such that the yield after subtraction is zero at its minimum (ZYAM)

Ajitanand et al. PRC **72**, 011902(R) (2005)

ZYAM implementation (I)

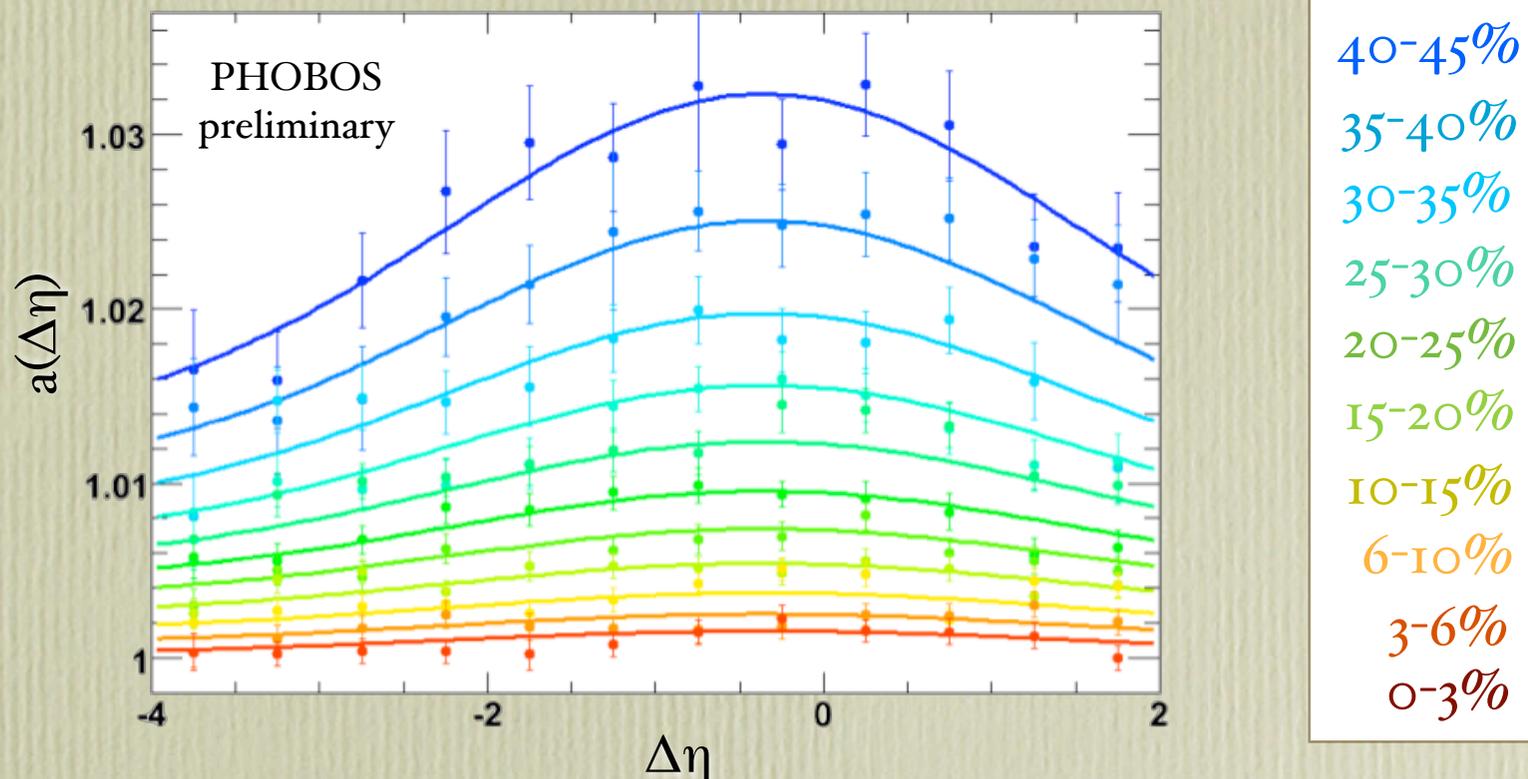
- Construct the ratio of the raw correlation over the flow modulation in 11 centrality bins and 12 $\Delta\eta$ slices
- Fit the region $20^\circ < \Delta\phi < 90^\circ$ to determine the minimum value
- Assign error from uncertainty on pol2 fit — and comparison to different techniques (e.g. ZYA1, \star avg. of three lowest points, - - - - avg. of 2nd + 3rd lowest points) - - - -



NB: huge error bars = spectrometer holes

ZYAM implementation (II)

ZYAM factors from 2d-fit in $\Delta\eta$ and N_{part}



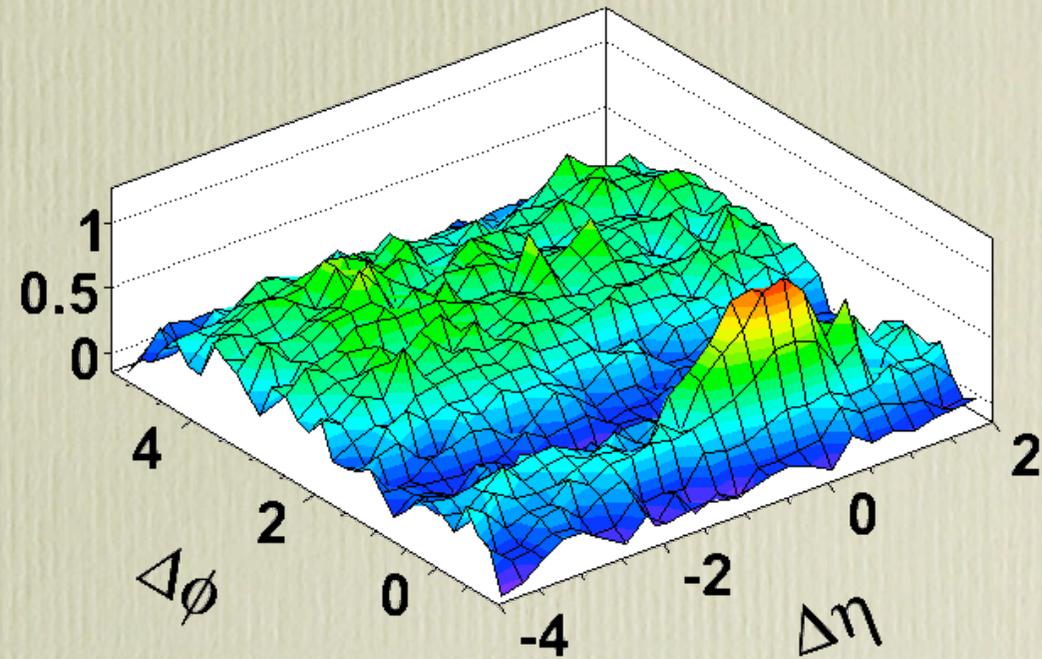
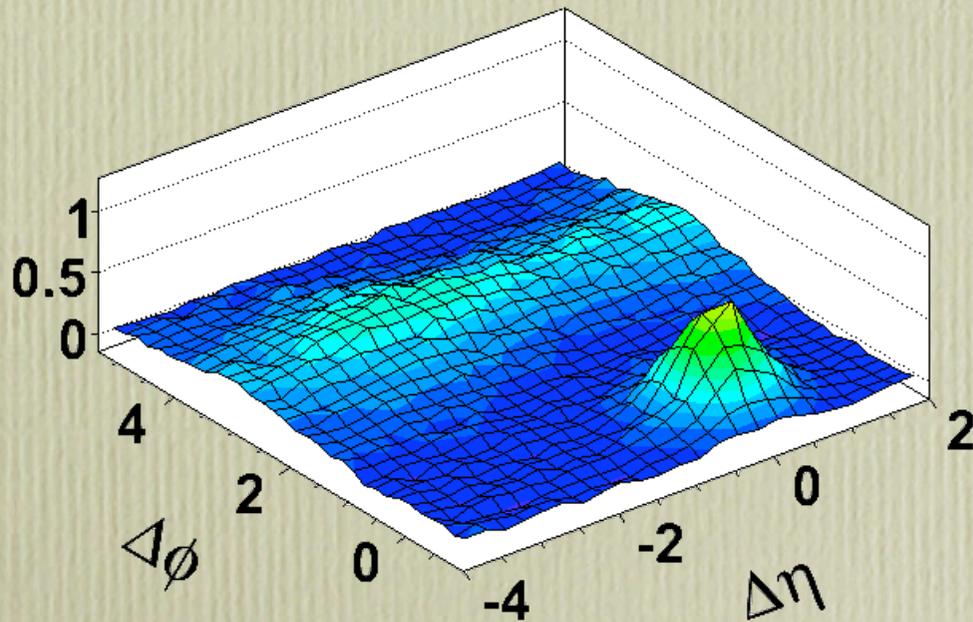
- **Constant term:** bias of the p_T -triggered signal distribution to higher multiplicity
 - **Gaussian term:** $\Delta\eta$ correlation structure underneath v_2 -subtracted $\Delta\phi$ correlations. Width/amplitude/ N_{part} -dependence same as inclusive correlations
- arXiv:0812.1172 (2008)

Correlated Yield Results in Au+Au vs. p+p

p+p
(PYTHIA)

$$\frac{1}{N_{\text{trig}}} \frac{d^2 N_{\text{ch}}}{d\Delta\phi d\Delta\eta}$$

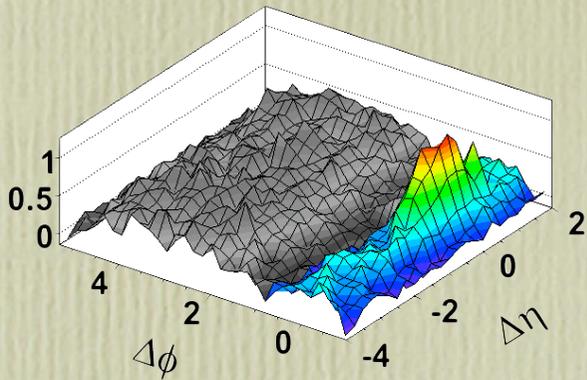
Au+Au 0-30%
PHOBOS preliminary



NB: PYTHIA agrees nicely with STAR at mid-rapidity for a similar set of p_T cuts

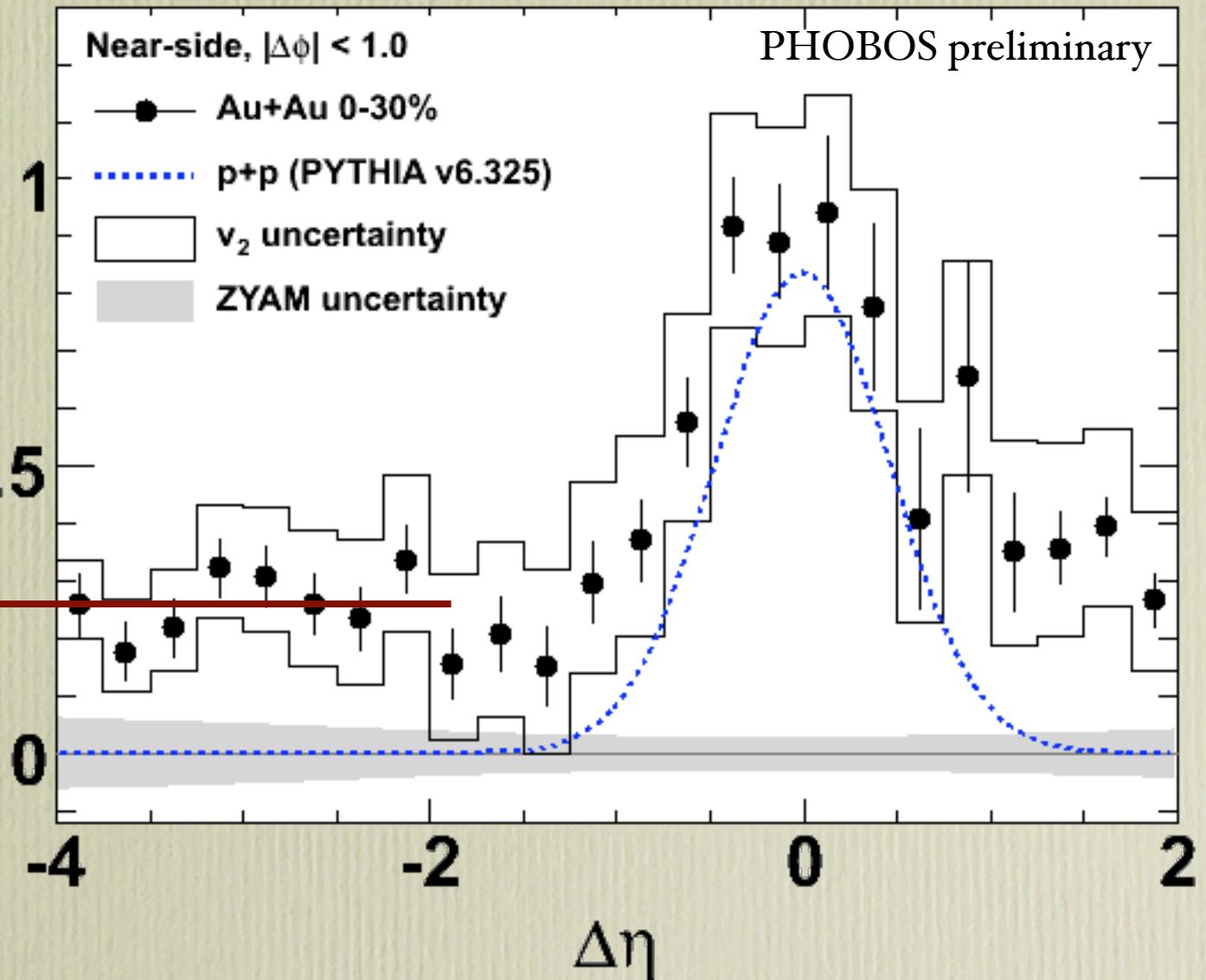
$p_T^{\text{trig}} > 2.5 \text{ GeV}/c$
 $p_T^{\text{assoc}} \cong 20 \text{ MeV}/c$

Ridge Extent in $\Delta\eta$



Long-range
ridge yield

$$\frac{1}{N_{\text{trig}}} \frac{dN_{\text{ch}}}{d\Delta\eta}$$

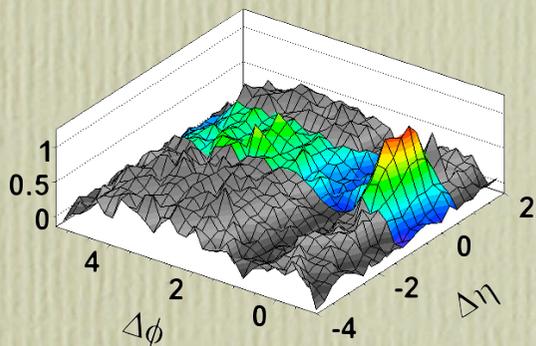
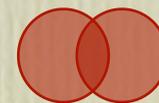


Projection of correlated yields in $\Delta\phi$

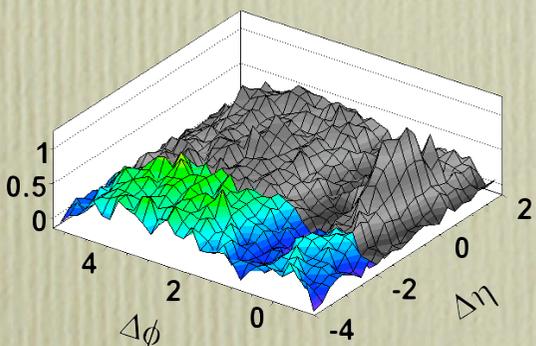
0-10%



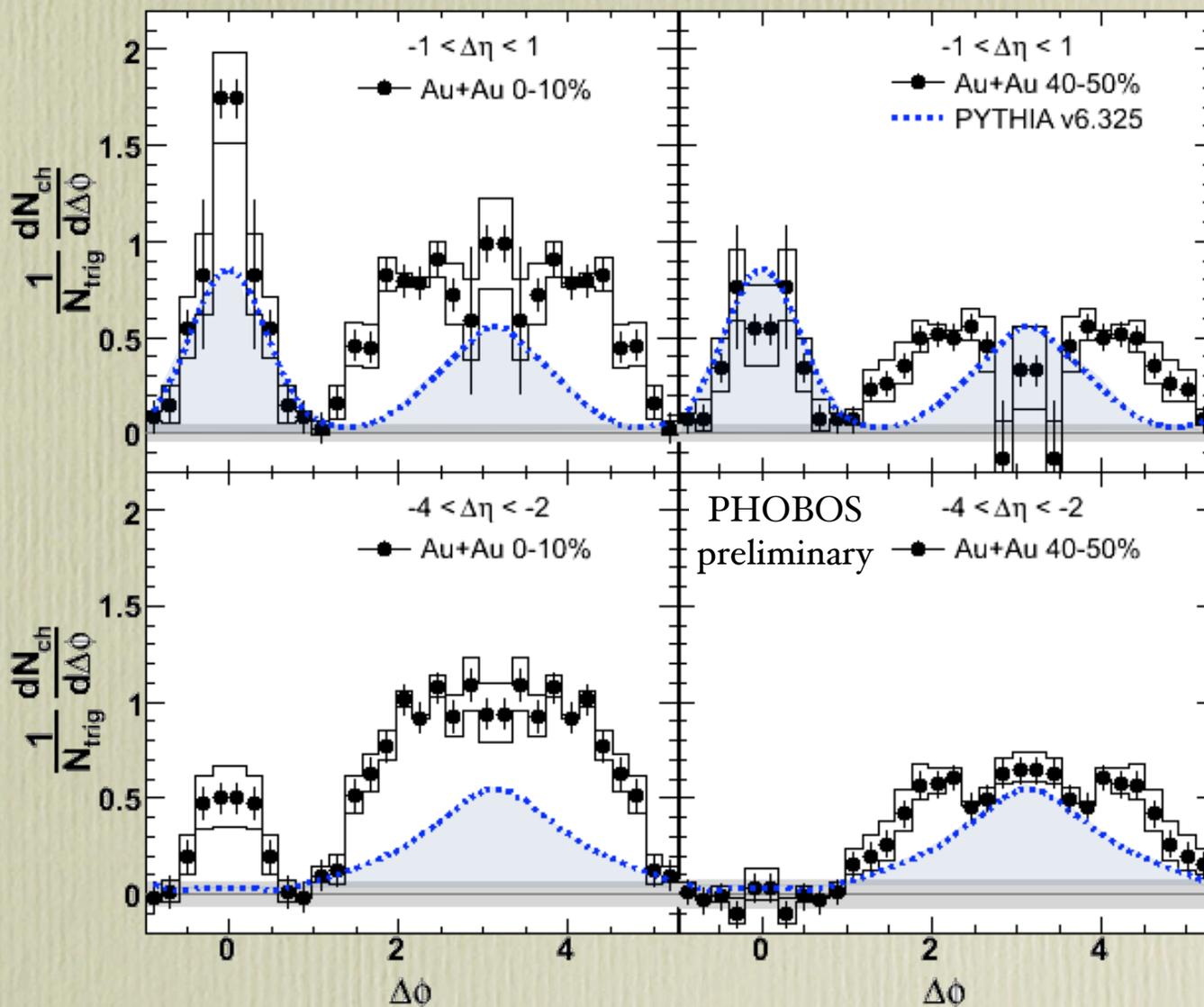
40-50%



Short-range
 $|\Delta\eta| < 1$



Long-range
 $-4 < \Delta\eta < -2$



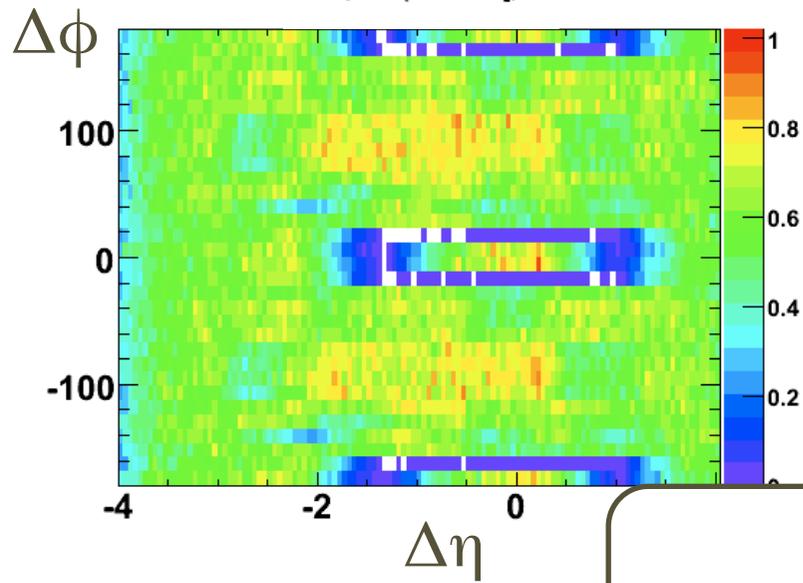
Summary

- PHOBOS can measure correlations over a broad range of $\Delta\eta$
- The $\Delta\eta$ -dependence of the ZYAM scale factor is evidence of short-range $\Delta\eta$ correlations with similar properties as seen in inclusive 2-particle correlations
- The ridge correlation extends to at least $\Delta\eta = 4$
- For a trigger particle of $2.5 \text{ GeV}/c$ and $p_T^{\text{assoc}} \gtrsim 20 \text{ MeV}/c$, the ridge correlation disappears around $N_{\text{part}} = 80$

Backup Slides

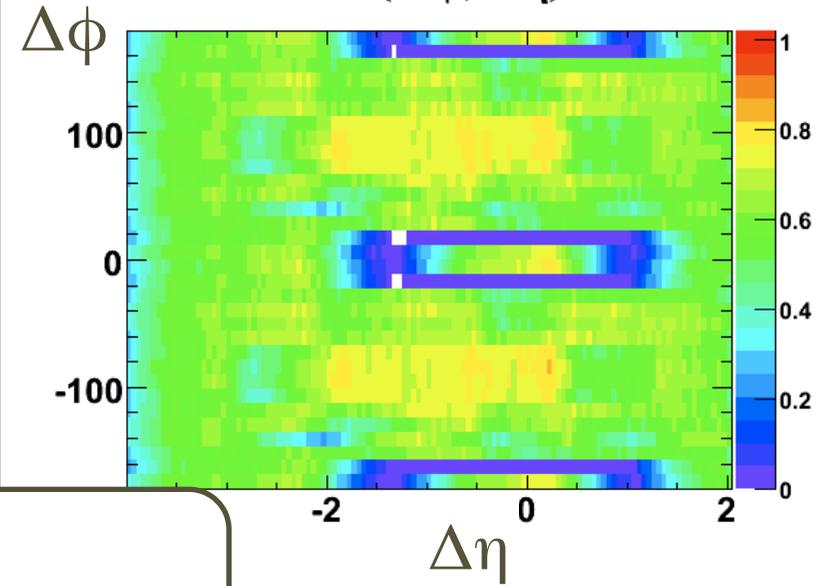
Triggered Pair Acceptance

$s(\Delta\phi, \Delta\eta)$

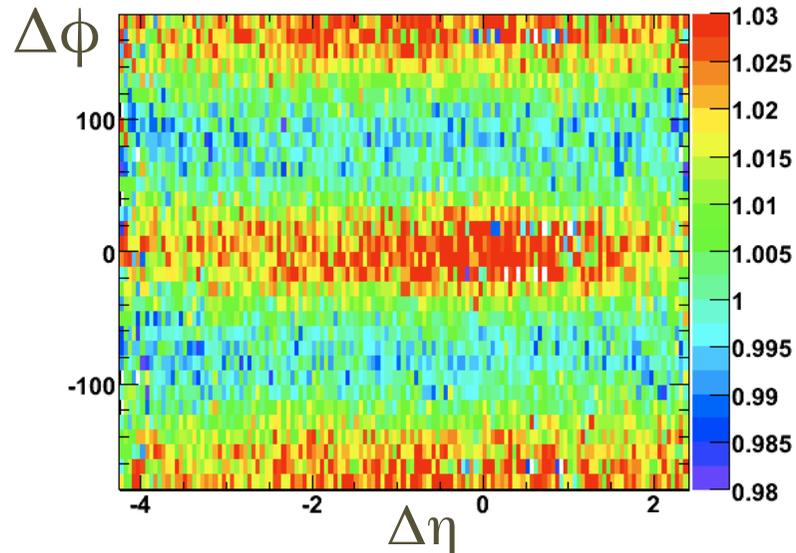


15-20% central
 $3\text{mm} < v_z < 4\text{mm}$

$b(\Delta\phi, \Delta\eta)$



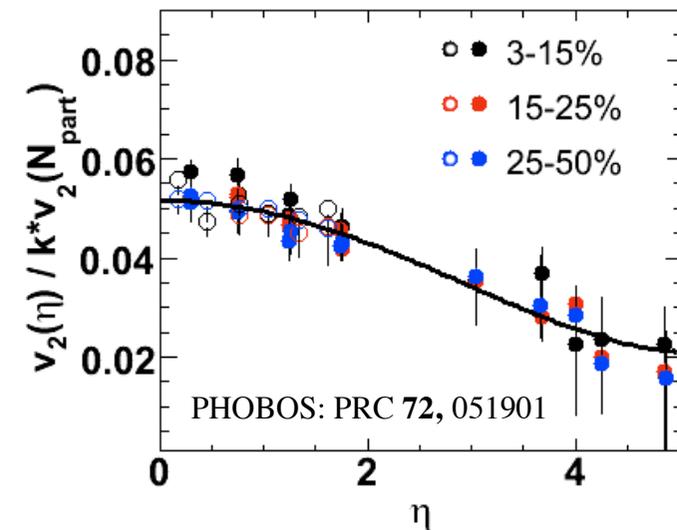
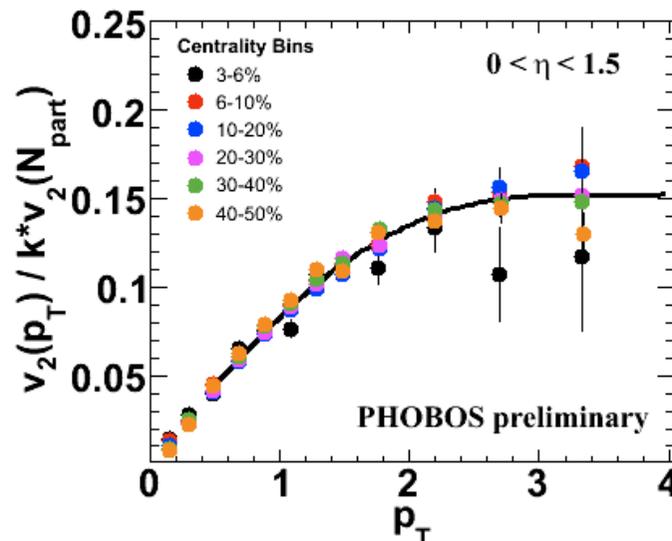
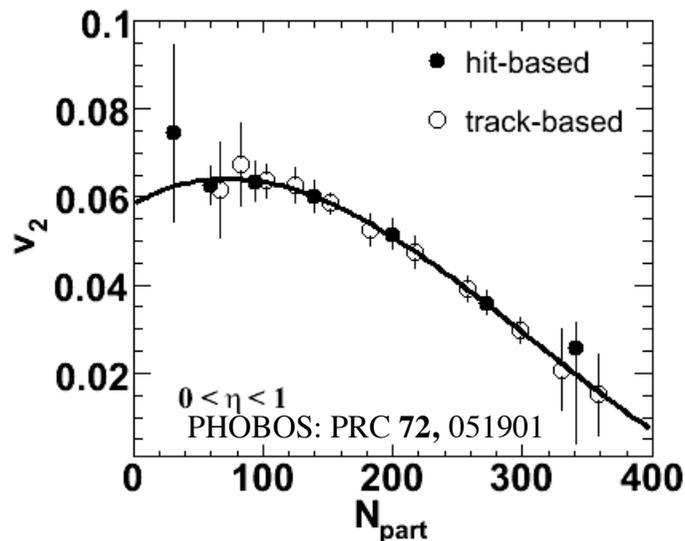
$\frac{s(\Delta\phi, \Delta\eta)}{b(\Delta\phi, \Delta\eta)}$



averaged over
 $-15\text{cm} < v_z < 10\text{cm}$

Estimating the Flow Term

- Parameterize published PHOBOS measurements as $v_2(N_{\text{part}}, p_T, \eta) = A(N_{\text{part}}) B(p_T) C(\eta)$



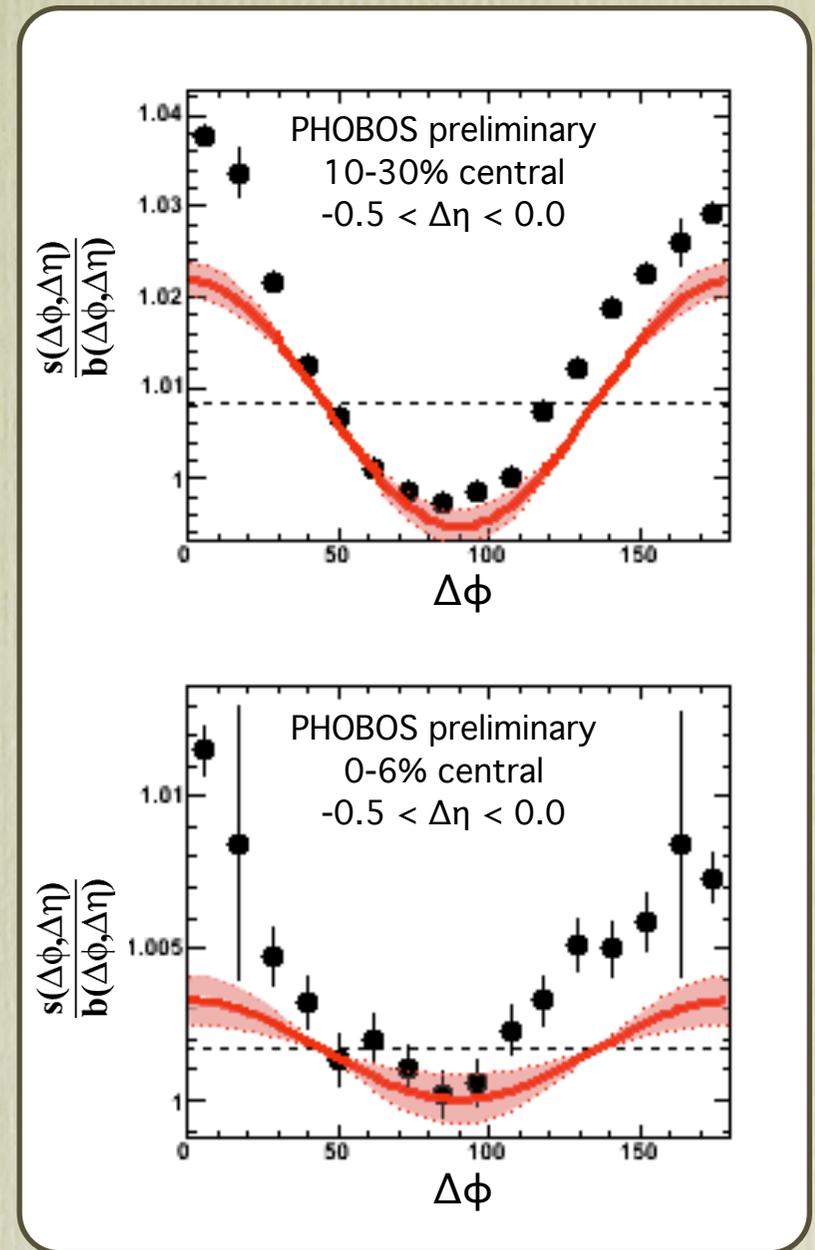
- Correct $v_2(N_{\text{part}}, \langle p_T^{\text{trig}} \rangle, \eta_{\text{trig}})$ for occupancy and $v_2(N_{\text{part}}, \langle p_T^{\text{assoc}} \rangle, \eta_{\text{assoc}})$ for secondaries

$$1 + 2V(\Delta\eta) \cos(2\Delta\phi)$$

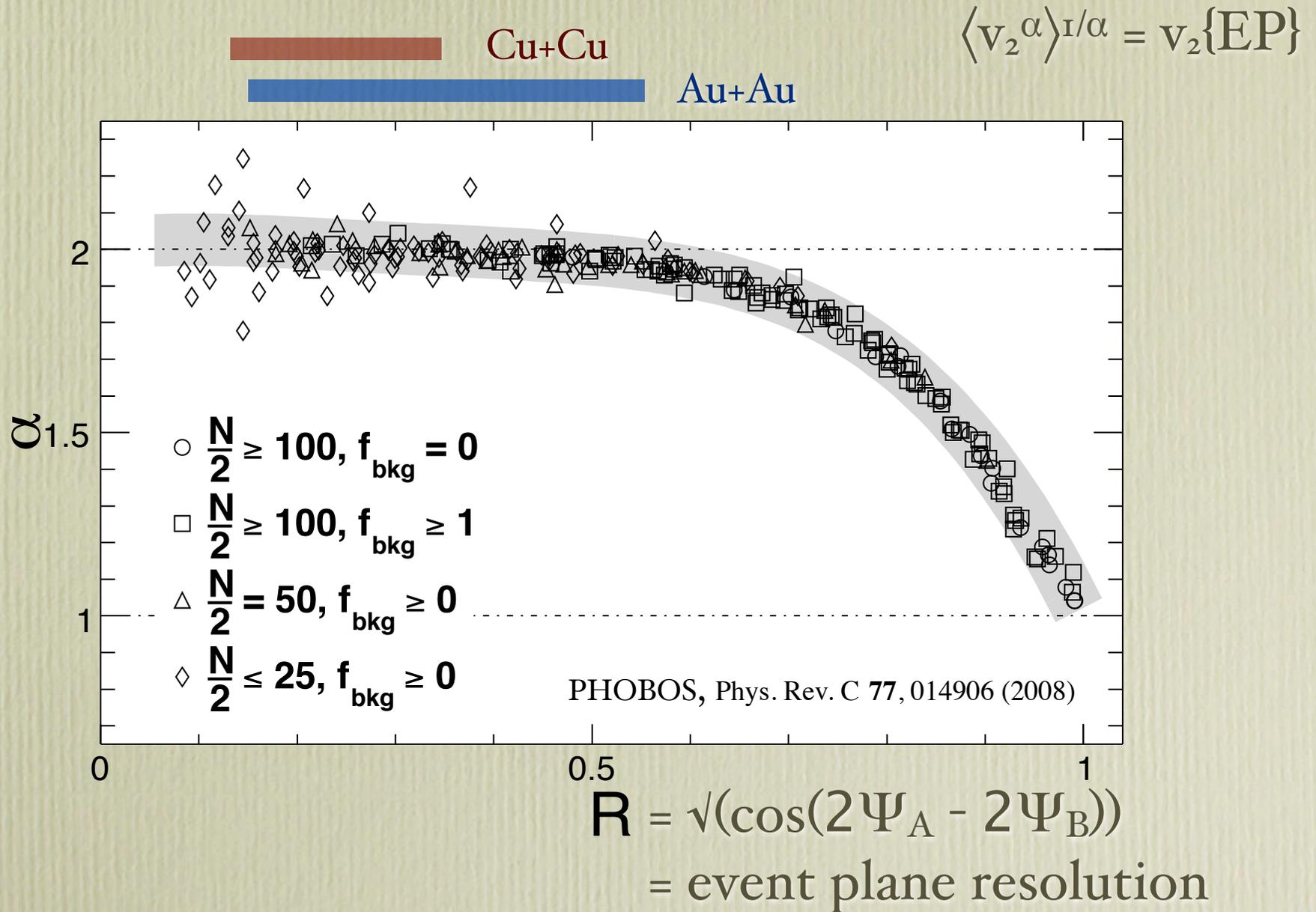
$$V = \langle v_2^{\text{trig}} \rangle \langle v_2^{\text{assoc}} \rangle$$

v_2 Subtraction Systematics

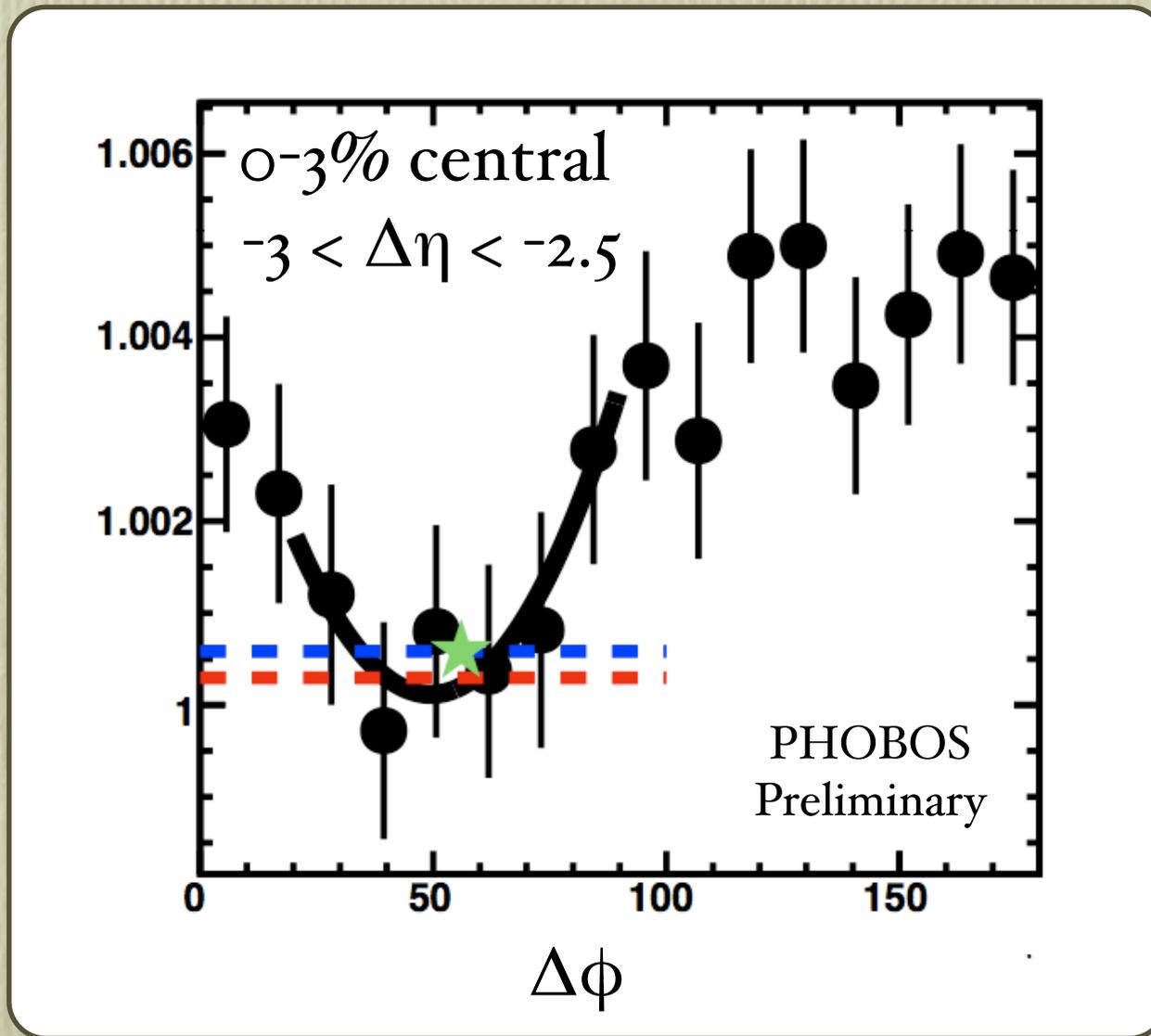
- The dominant systematic error in this analysis is the uncertainty on the magnitude of $\mathbf{v}_2^{\text{trig}} \mathbf{v}_2^{\text{assoc}}$
 - $\sim 14\%$ error on $\mathbf{v}_2^{\text{trig}} \mathbf{v}_2^{\text{assoc}}$ ($\eta=0$)
 - $\sim 20\%$ error on $\mathbf{v}_2^{\text{trig}} \mathbf{v}_2^{\text{assoc}}$ ($\eta=3$)
 - In the most central collision -- where flow is small compared to the correlation -- the error on $\mathbf{v}_2^{\text{trig}} \mathbf{v}_2^{\text{assoc}}$ can exceed 50% .



RMS vs. Mean v_2

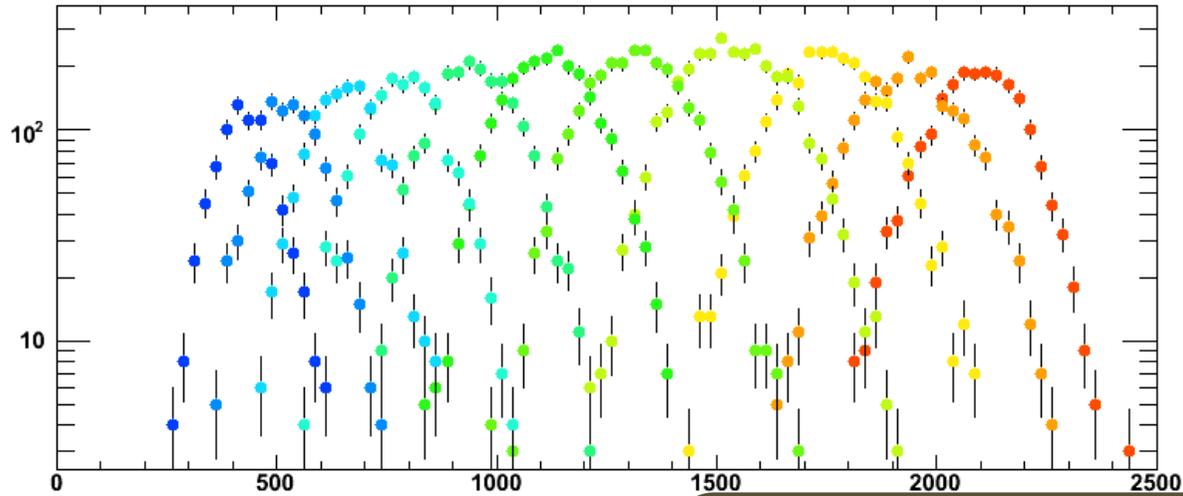


Correlation / Flow



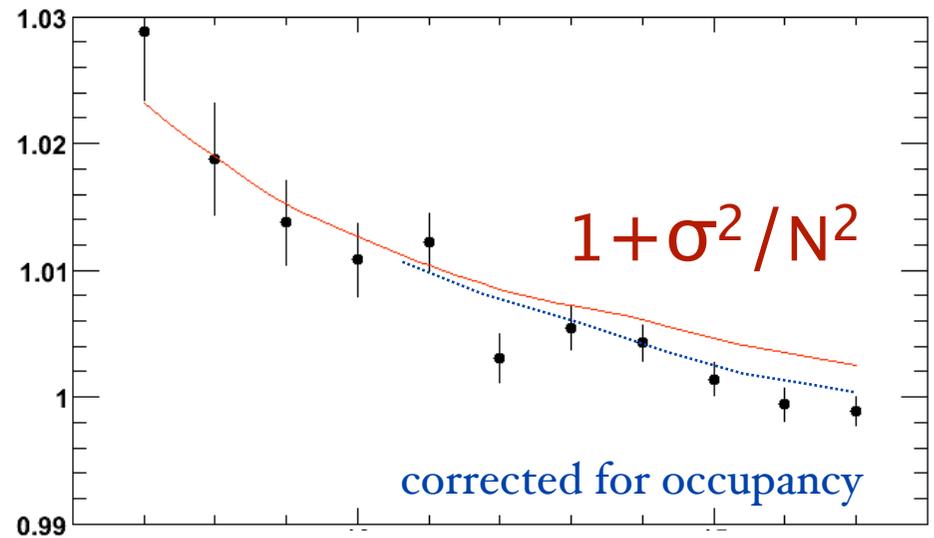
Centrality dependence of ZYAM

Number of octagon hits distribution for different centralities



σ/N = relative width
of centrality bin

Ratio of octagon hit multiplicities (triggered / untriggered)

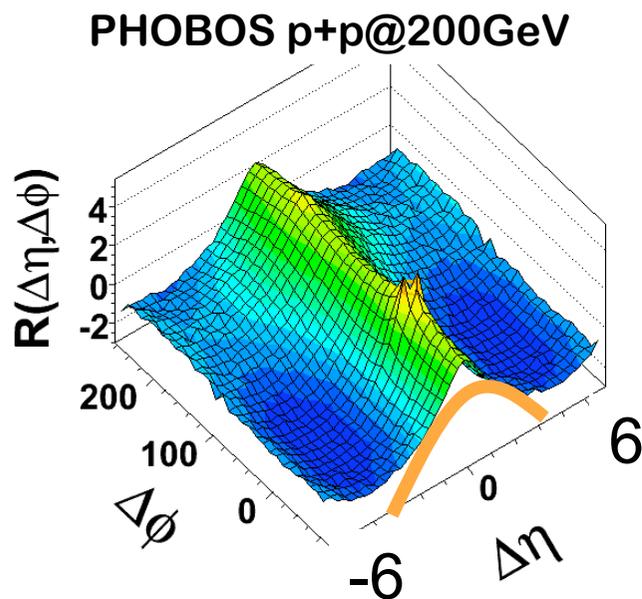


45-50% Centrality Bin 0-3%

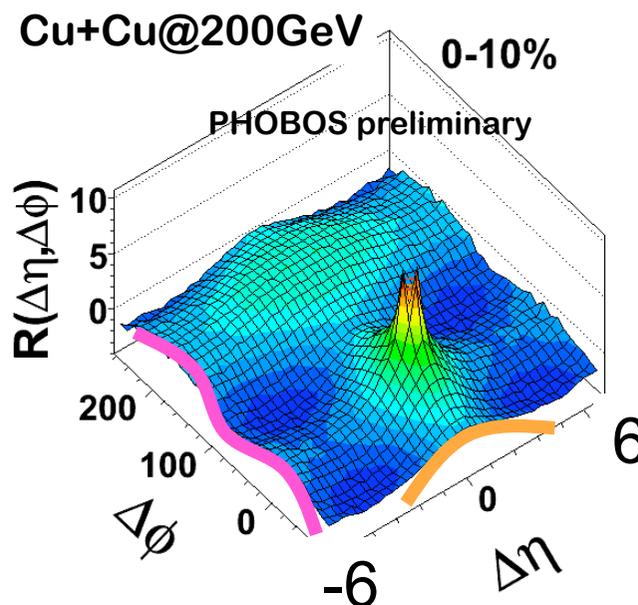
2-particle Inclusive Correlations

multiplicity independent
2-particle correlations

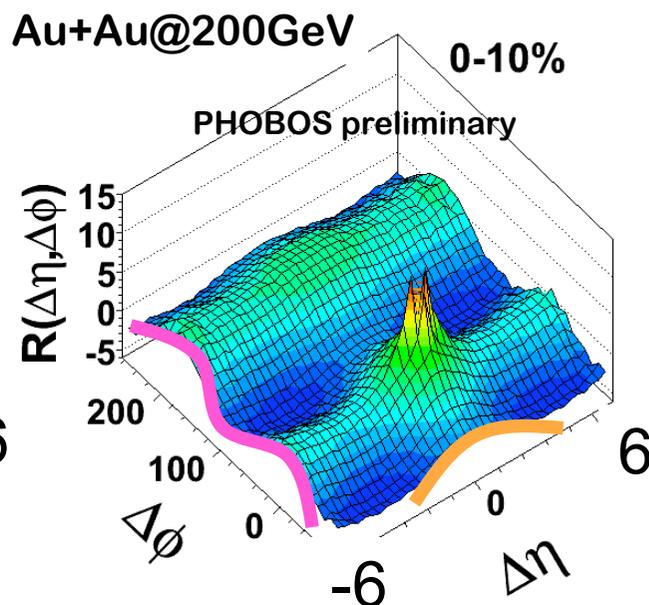
$$R(\Delta\eta, \Delta\phi) = \langle (n-1) \left(\frac{F_n(\Delta\eta, \Delta\phi)}{B_n(\Delta\eta, \Delta\phi)} - 1 \right) \rangle$$



Phys. Rev. C75 (2007) 054913



J. Phys. G34 (2007) s1005

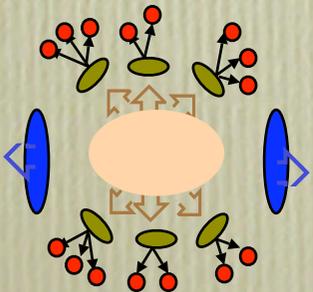
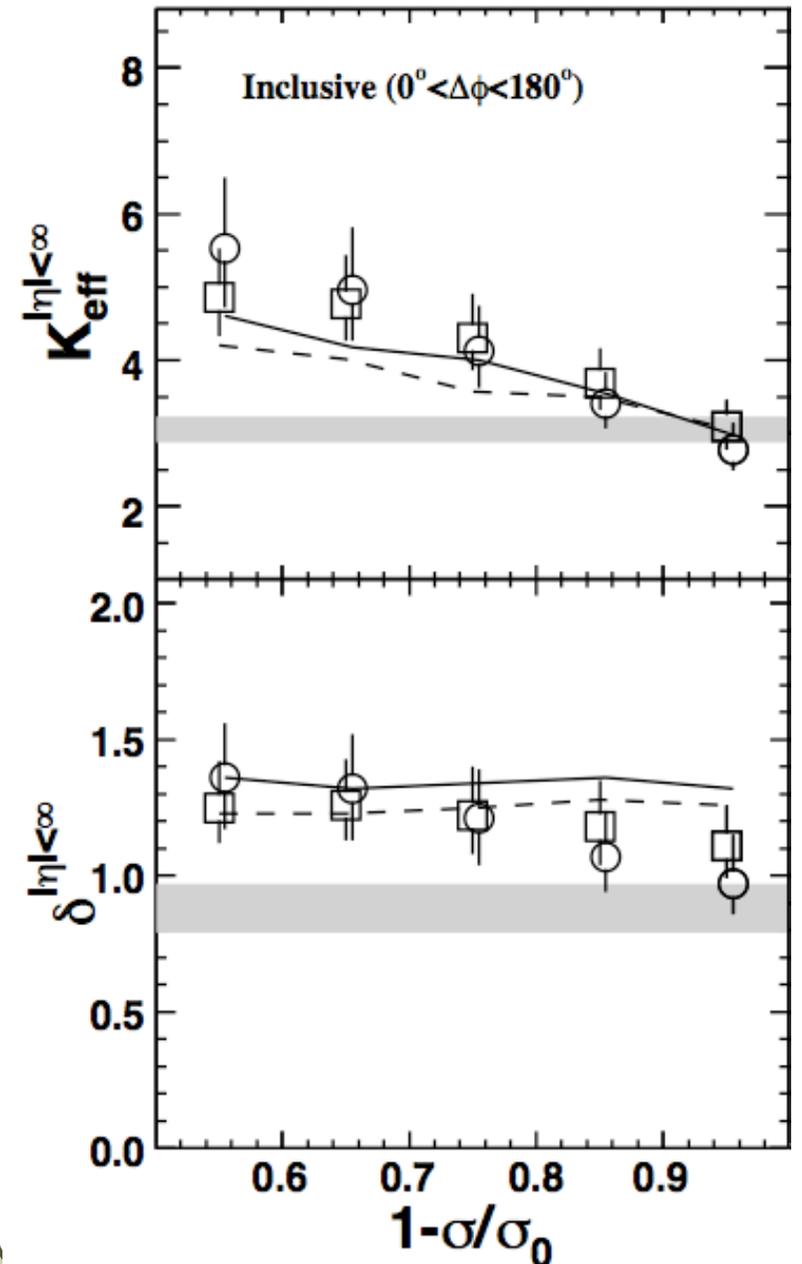
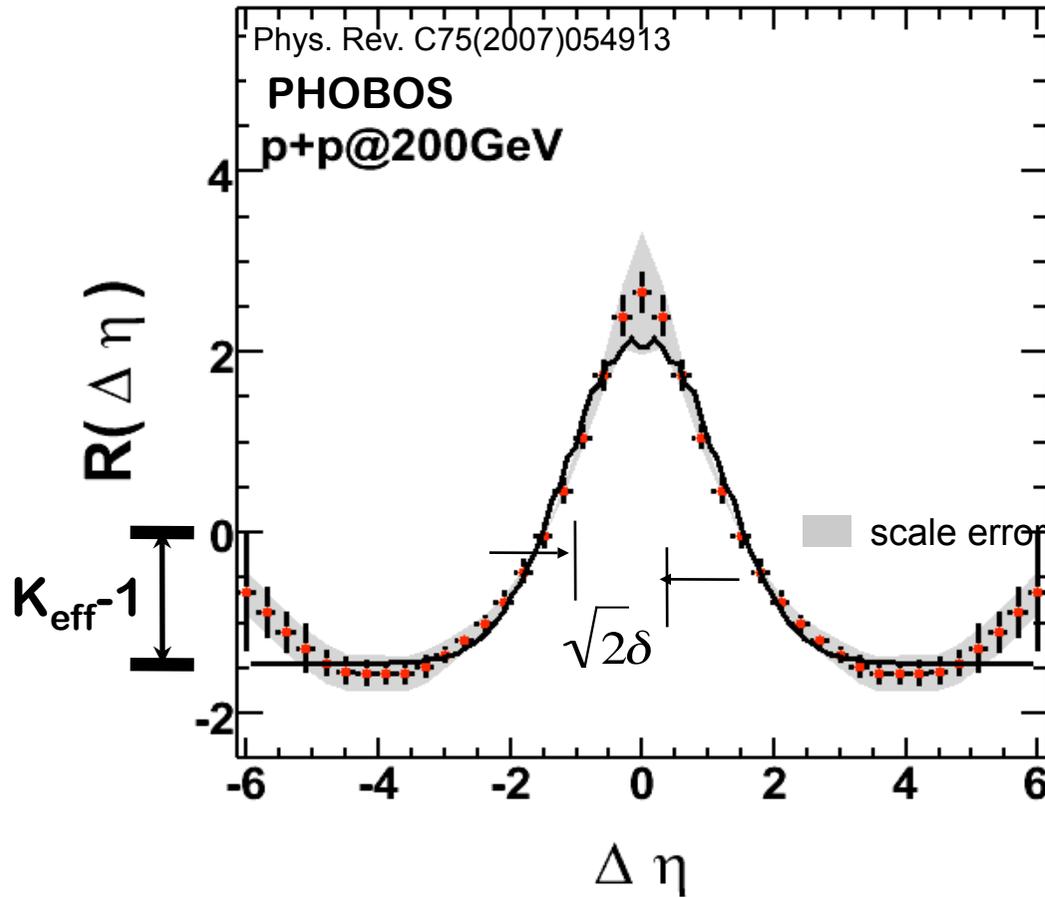


arXiv:0812.1172 (2008)

v_2 component: $\langle 2(n-1)v_2^2 \rangle$

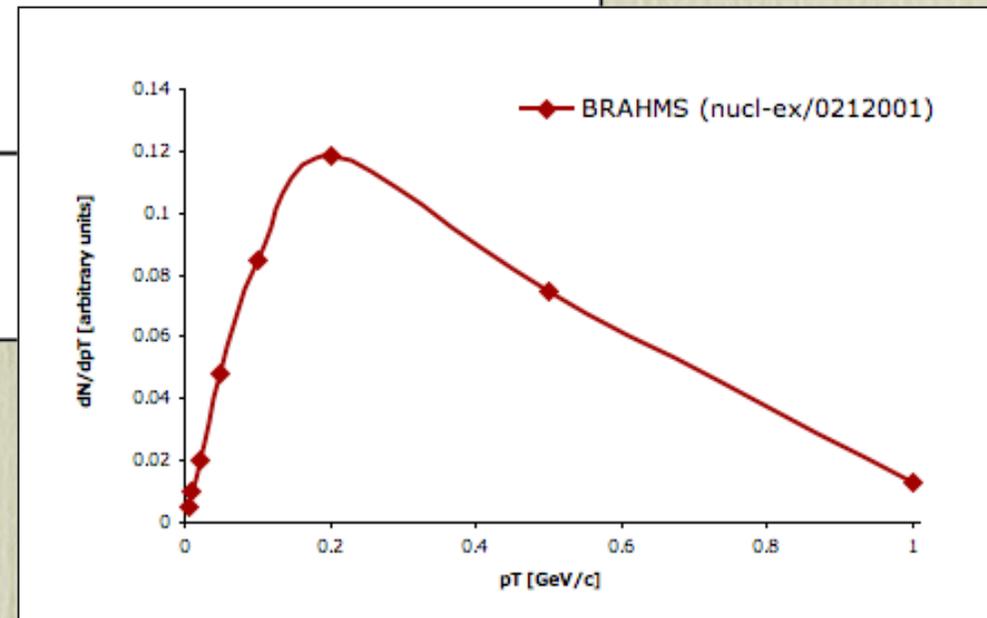
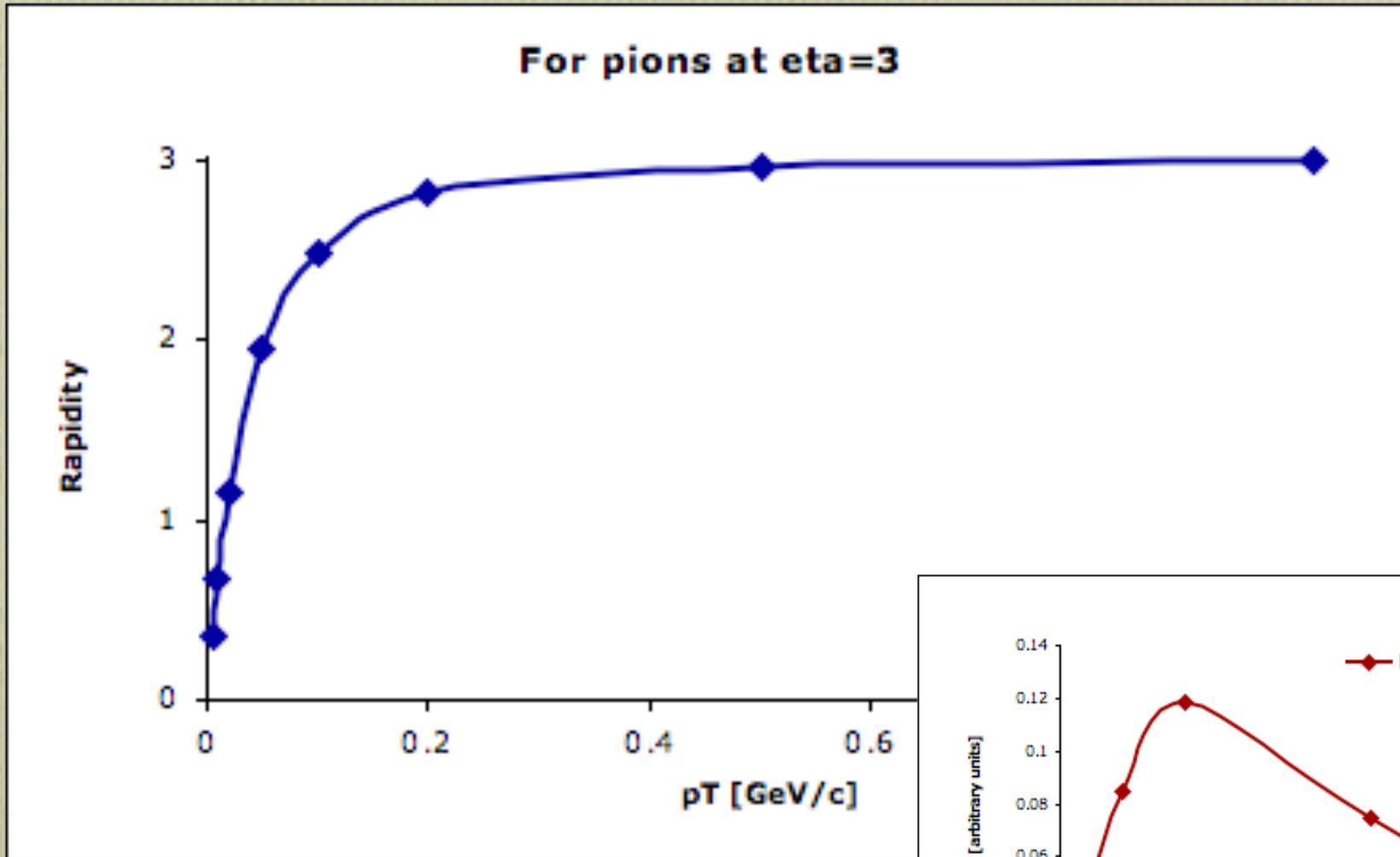
Cluster size and width

$$R(\Delta\eta, \Delta\phi) = \langle (n-1) \left(\frac{F_n(\Delta\eta, \Delta\phi)}{B_n(\Delta\eta, \Delta\phi)} - 1 \right) \rangle$$

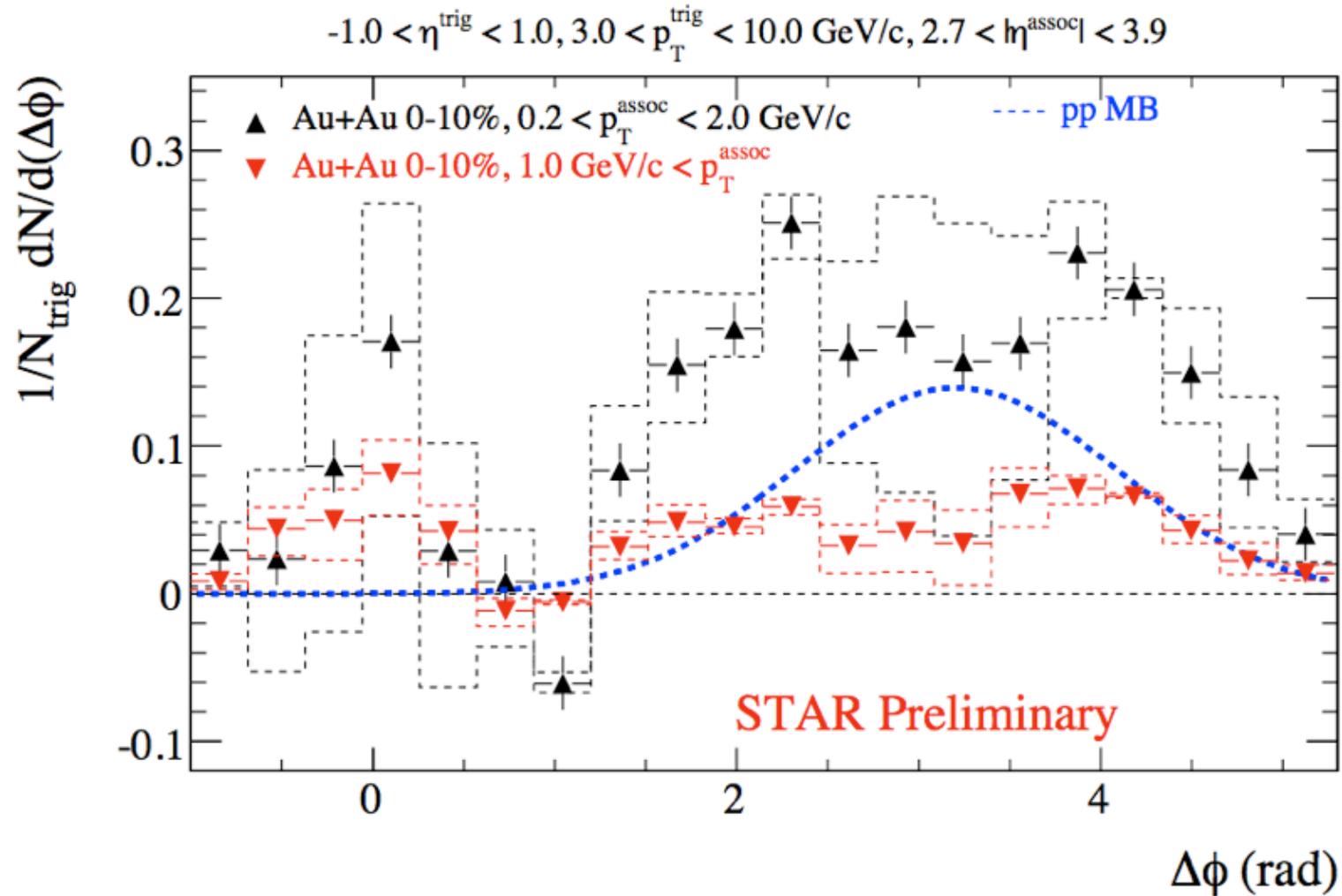


K_{eff} : effective cluster size
 $\sqrt{2}\delta$: cluster decay width

Pseudorapidity versus Rapidity

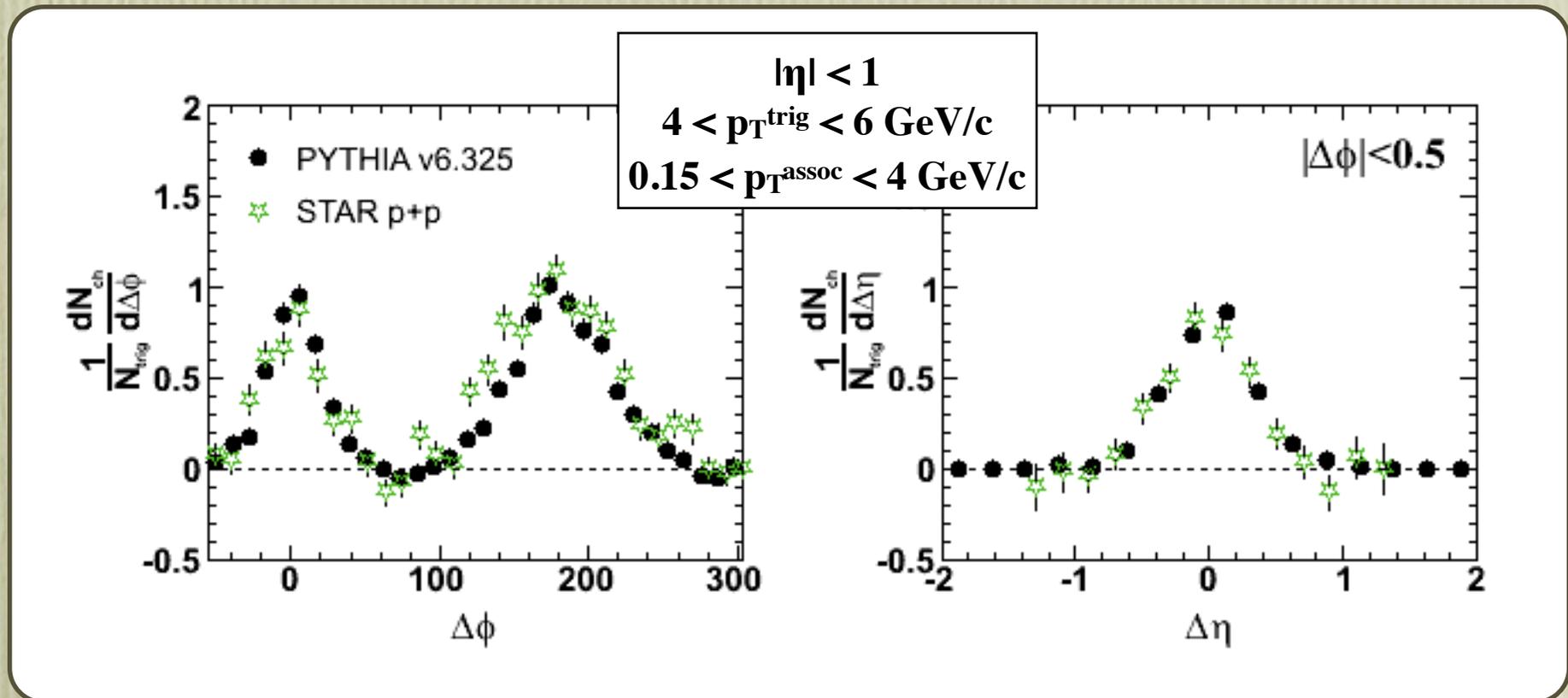


FTPC-TPC Correlation (STAR)



STAR vs. PYTHIA

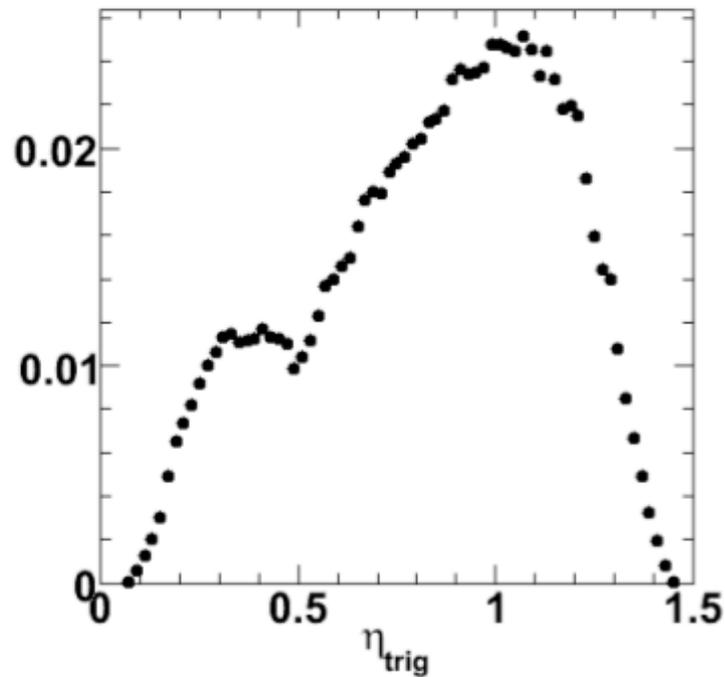
- PHOBOS is limited by statistics in p+p
- We will compare our Au+Au results to PYTHIA, which reasonably reproduces STAR p+p data



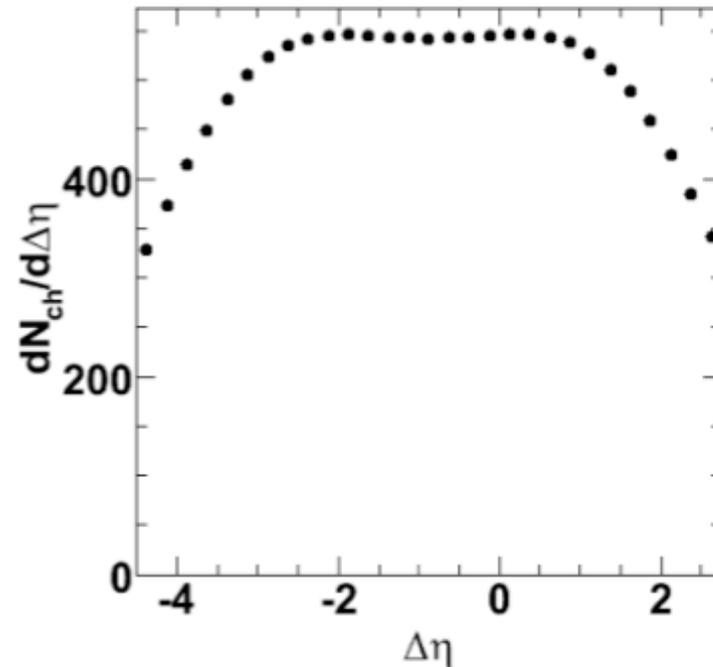
Normalization Term $B(\Delta\eta)$

$$\frac{1}{N_{\text{trig}}} \frac{d^2 N_{\text{ch}}}{d\Delta\phi d\Delta\eta} = \mathbf{B}(\Delta\eta) \left\{ \frac{s(\Delta\phi, \Delta\eta)}{b(\Delta\phi, \Delta\eta)} - a(\Delta\eta) [1 + 2V(\Delta\eta) \cos(2\Delta\phi)] \right\}$$

Trigger η distribution



Convolutd with
published $dN_{\text{ch}}/d\eta$



Trigger η vs. z -vertex position

